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Verifiable Decision-Making Algorithms for Reconfiguration of Electric Microgrids

Collaborators: Colorado State University (PI – S. Suryanarayanan; S. Rajopadhye, S. Natarajan)
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Colorado School of Mines (J. Giráldez*; Advisor – S. Suryanarayanan)
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Project Description

We hope to discover new algorithms for reconfiguration of electric power microgrids subject to specific objectives such as maximized economic benefits and minimized losses. We will use detailed modeling and simulation for validation of these algorithms and ideas from machine learning to cut down on the simulation effort, addressing issues such as reliability. The research is expected to yield new topologies and operations aspects of electric power microgrids that will accelerate the penetration of renewables in the grid. This project builds on results obtained by researchers at CSM through funding from PSERC (T-41) and supplementary funds from CSU Energy Supercluster seed grant.

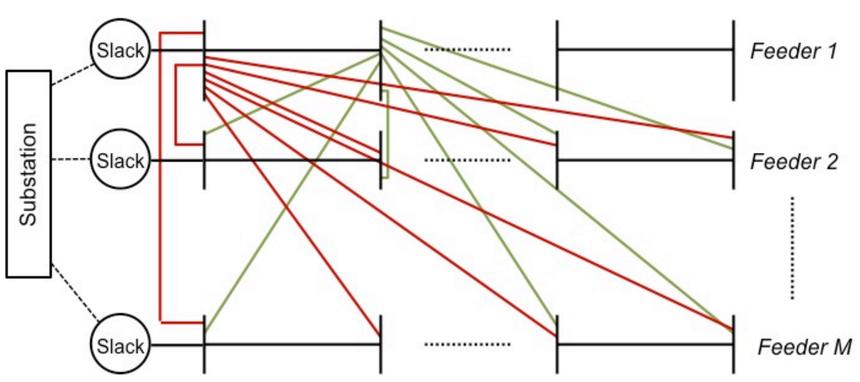


Figure 1. Possible candidates for intertie additions between feeders in notional distribution system.

Expected Outcomes and Applications

Expected outcome is in the area of verifiable algorithms for microgrid design. As microgrids are poised to increase to ~3-4.5 GW installed capacity and capture $1.75-3.5 billions in market, worldwide, development of algorithms for the design of microgrids becomes highly relevant. Microgrids are expected to evolve from the existing 'legacy' distribution grids by addition of distributed sources and feeder interties among other enabling technologies. A major thrust of this research is that algorithms developed for microgrid design adhere to verification techniques; thus, providing avenues for identifying optimum toplogies and accelerating the time toward the solution.

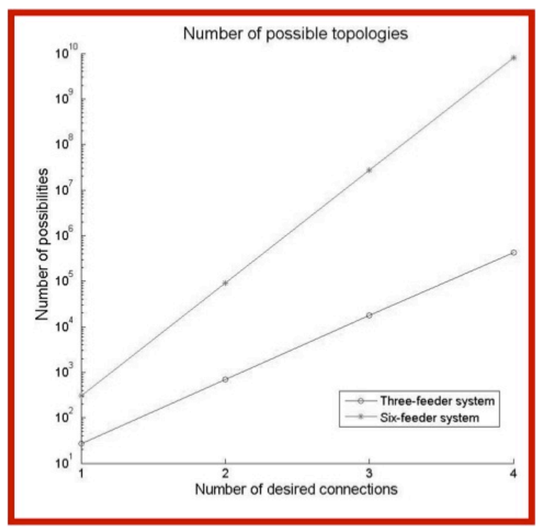
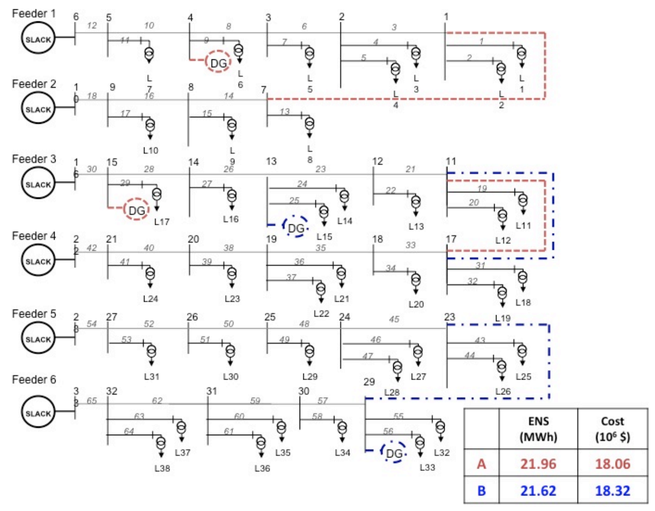


Figure 2. Number of possible topologies as a function of number of desired connections.



	ENS (MWh)	Cost (10^6 $)
A	21.96	18.06
B	21.62	18.32

Figure 3. Results of reconfiguration in the RBTS system showing two possible solutions.

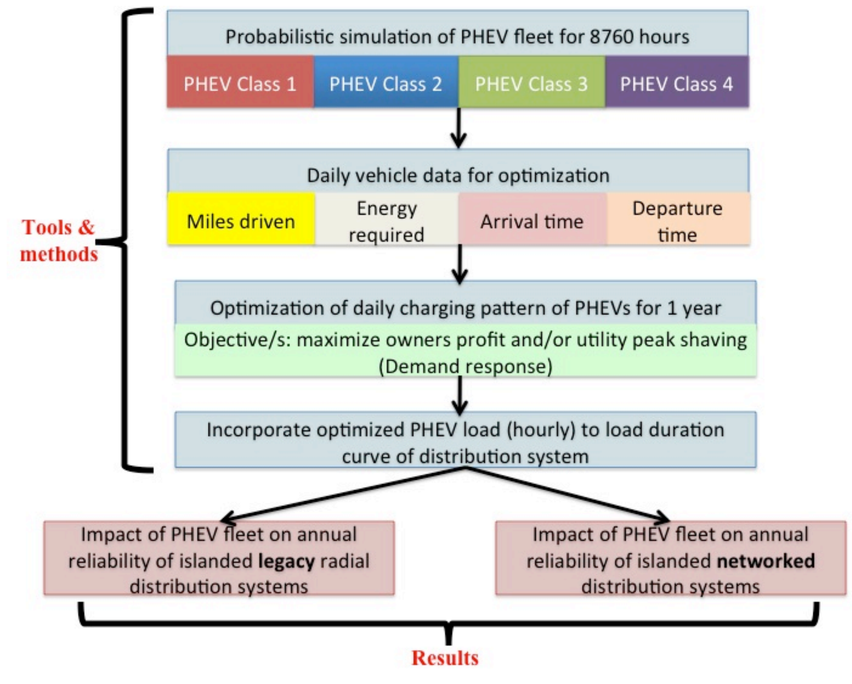


Figure 4. Flowchart of tools/methods and results for quantifying impact of PHEVs in distribution systems.

Accomplishments

1 Collocation of distributed generation sources and network interties in legacy radial distribution system using evolutionary algorithms (CSU, CSM)
2 Quantifying impact of plug-in hybrid vehicles on radial distribution systems and microgrids (CSU, CSM)
3 Quantifying growth of feeder additional problem (CSU)
4 Classifying/reducing microgrid design problem to *NP*-complete (CSU, collaboration with Dr. Rajopadhye, CS, CSU)
5 Use of machine learning to reduce overhead of simulations (CU)
6 Use of code acceleration methods to reduce overhead of simulations (CSU)
7 Publications:
   a. J. Giráldez, J. Walz, H. E. Brown, S. Suryanarayanan, S. Sankaranarayanan, E. Chang, "An evolutionary algorithm and acceleration approach for topological design of distributed resource island," in Proc. 2011 IEEE PES PowerTech, Trondheim, Norway, pp. 1-8, Jun 2011.
   b. J. Giráldez, "Some aspects in design of smart distribution systems – islands, microgrids, and plug-in hybrid electric vehicles,", MS thesis, Division of Engineering, Colorado School of Mines, May 2011.
   c. S. A. Natarajan, "Computational complexity in the design of microgrids and an algorithm for blackstarting a notional mission-specific microgrid," under preparation, MS thesis, Dept. of ECE, Colorado State University, May 2012.
8 Presentations:
   a. J. Giráldez, "A multi-objective genetic algorithmic approach for optimal allocation of distributed generation and feeder interties considering reliability and cost," submitted, student poster contest, IEEE PES Power Systems Conference and Exposition, Phoenix, AZ, Mar 2011.
   b. J. Giráldez, S. Suryanarayanan, S. Sankaranarayanan, "Modeling and simulation aspects of topological design of distributed resource islands," Joint Institute for Strategic Energy Analysis (JISEA), Nat'l Renewable Energy Lab (NREL). [Online] {Available} http://www.jisea.org/pdfs/20101214_seminar.pdf (Dec 2010).

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